

What is claimed is:

1. A method for simulating one or more characteristics of a multi-component, hydrocarbon-bearing formation wherein a fluid comprising at least one component is injected into the formation through at least one well to displace hydrocarbons in the reservoir, comprising the steps of:
  - (a) equating the formation in at least one dimension to a multiplicity of gridcells;
  - (b) dividing at least some of the gridcells into two or more regions, a first region representing a portion of each gridcell swept by the displacement fluid and a second region representing a portion of each gridcell essentially unswept by the injected fluid, the distribution of components in each region being essentially uniform;
  - (c) constructing a model representative of fluid properties within each region, fluid flow between gridcells using principles of percolation theory, and component transport rate between regions; and
  - (d) using the model to simulate one or more characteristics of the formation.
2. The method of claim 1 wherein step (d) predicts a property of the formation and the fluids it contains as a function of time.
3. The method of claim 1 wherein the displacement fluid is miscible with hydrocarbons in the formation.
4. The method of claim 1 wherein the displacement fluid is multiple-contact miscible with hydrocarbons present in the formation.
5. The method of claim 1 wherein the displacement fluid is carbon dioxide.
6. The method of claim 1 wherein the displacement fluid comprises hydrocarbon gas.

7. The method of claim 1 wherein model constructed in step (c) is further representative of energy transport between gridcell regions.
- 5 8. The method of claim 1 wherein the displacement fluid is steam and the model of step (c) is further representative of energy transport between gridcell regions.
9. The method of claim 1 wherein the gridcells comprises unstructured gridcells.
- 10 10. The method of claim 1 wherein the gridcells are three-dimensional.
11. The method of claim 1 wherein the gridcells are two-dimensional.
- 15 12. The method of claim 1 wherein the model further takes into account component diffusion, dispersivity, and interfacial tension within each region.
13. The method of claim 1 wherein the component transport rate between regions is proportional to the driving force times resistance.

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14. A method for simulating one or more characteristics of a multi-component, hydrocarbon-bearing formation into which a displacement fluid is injected to displace formation hydrocarbons present in the formation, comprising
- (a) equating at least part of the formation to a multiplicity of gridcells;
  - (b) dividing each gridcell into two regions, a first region representing a solvent-swept portion of each gridcell and a second region representing a portion of each gridcell essentially unswept by the solvent, the fluid composition within each region being essentially uniform;
  - (c) constructing a model comprising functions representative of the mobility of each phase in each region using principles of percolation theory, functions representative of the phase behavior within each region, and functions representative of the mass transfer of each component between the regions; and
  - (d) using the model in a simulator to simulate production of the formation and to determine one or more characteristics thereof.
15. The method of claim 14 wherein steps (a) through (d) are repeated for a plurality of time intervals and using the results to predict a property of the reservoir and the fluids it contains as a function of time.

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16. A system for determining one or more characteristics of a multi-component, hydrocarbon-bearing formation into which a displacement fluid having at least one component is injected to displace formation hydrocarbons, said model using a multiplicity of gridcells being representative of the formation, comprising
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- (a) a model having each gridcell divided into two regions, a first region representing a portion of each gridcell swept by the displacement fluid and a second region representing a portion of each gridcell essentially unswept by the displacement fluid, the distribution of components in each region being essentially uniform and the mobility of fluids in each region being determined based on principles of percolation theory; and
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- (b) a simulator, coupled to said model, to simulate the formation to determine the characteristic therefrom.
- 15 17. The system of claim 16 wherein the model is representative of fluid properties within each region, fluid flow between gridcells, and component transport between regions.
18. A method of simulating at least one component of a multicomponent fluid system in a hydrocarbon-bearing formation, whose characterizing features are described by a set of equations, by means of a simulator on a computer, the method comprising the steps of:
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- (a) providing a model having each gridcell divided into two regions, a first region representing a portion of each gridcell swept by the displacement fluid and a second region representing a portion of each gridcell essentially unswept by the displacement fluid, the distribution of components in each region being essentially uniform and the mobility of fluids in each region being determined based on principles of percolation theory; and
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- (b) using in the simulator the model thereby simulating changes of the component in the formation.
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